

**Original Research Paper**

## **Influence of floral and aromatic plant materials on incense stick preparation and properties**

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### **ABSTRACT**

In India, floral waste is disposed of in rivers and water bodies annually, leading to significant pollution. However, this waste can be substantially reduced if utilized effectively. One promising application is the use of floral waste in the production of value-added products. This study specifically explores the potential of repurposing waste to manufacture incense sticks. Two experiments were conducted to identify the optimal combination of flower petal powder and adhesives for making incense sticks. In experiment 1, sixteen different treatments of flower petal powder and adhesive combinations were tested. The treatment consisted of rose petal powder 42.5% and marigold petal powder 42.5% mixed with 15% Jigat powder as adhesive was found to be the most effective, followed by a combination of marigold petal powder 85% and 15% Jigat powder as adhesive. In experiment 2, the two best treatments from experiment 1 were mixed with aromatic plant powder in various proportions to create naturally fragrant incense sticks. The mosquito repellent activity and olfactory evaluation of these incense sticks were assessed. It was observed that the combination of rose petals, marigold petals, Jigat powder, and 30% lemongrass powder yielded the best results.

**Keywords:** Flowers, fragrance, incense sticks, insect repellent, waste recycling

### **INTRODUCTION**

Religious worship and cultural ceremonies in India generate substantial floral waste from various sources, including temples, hotels, marriages, gardens, churches, and Dargahs, where offerings like flowers are common (Chauhan et al., 2024). Floral offerings significantly contribute to temple waste in India (Waghmode et al., 2018). After serving their ritualistic purpose, these flowers often end up in garbage in water bodies, or open spaces, leading to environmental issues. The slow degradation of floral waste, compared to kitchen waste, exacerbates these problems and underscores the need for eco-friendly disposal methods (Ranjan & Goel, 2022). Annually, an estimated 800 metric tons of flowers are offered at places of worship, with over 8 metric tons discarded into water bodies (Raja et al., 2023). Despite the significant volume of flower waste, it is often overlooked in waste management practices. For example, Banaras, a major religious center, lacks effective policies for managing the 3.5-4 tonnes of daily temple waste. The improper disposal of this waste contributes to landfill overflow and environmental degradation (Mishra, 2013).

Repurposing floral waste into products like incense sticks offers a sustainable solution to waste disposal while supporting the floriculture industry. Currently, many commercial incense sticks use artificial scents. However, natural aromatic plants can produce eco-friendly, anti-microbial, and insect-repellent incense sticks (Reddy & Sirisha, 2024). Despite this potential, limited scientific research has been conducted on utilizing floral waste and aromatic plants for incense production (Agarwal & Jain, 2024). Keeping in view the importance of sustainable waste management the present study was carried out with the objectives to identify suitable flowers and adhesives for making incense sticks and to determine the optimal ratio of flower petal powder and aromatic plant powder for producing naturally fragrant incense sticks. This research will explore the feasibility of this approach, aiming to identify the best flower types and adhesive combinations and determine the ideal mix of flower petals and aromatic plant powders to create naturally scented incense sticks. This solution promises to reduce environmental pollution and promote sustainable practices within India's religious and cultural traditions.



## MATERIALS AND METHOD

The experiment was conducted in the floral craft lab of the Department of Floriculture and Landscape Architecture of Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan during 2021-2022, geographically located at 30° 52' 02" N latitude and 77° 11' 30" E at an elevation of 1275 m above mean sea level, which falls under the mid hill agro-climatic zone of Himachal Pradesh, India.

Two experiments were carried out with different plant sources such as three flower crops, four were aromatic crops and two adhesive agents (Table 1). In the first experiment, various flower petals and adhesive agents were tested for making incense sticks, resulting in 16 different treatment combinations (Table 2). The

incense stick preparation for experiment 1 is presented in Fig. 1.

In the second experiment, the two best treatments from the first experiment i.e. T<sub>12</sub>: 42.5% rose + 42.5% marigold + 15% Jigat powder followed by T<sub>10</sub>: 85% marigold + 15% Jigat powder were combined with four aromatic plant powders i.e. clove (*Syzygium aromaticum*), geranium (*Pelargonium graveolens*), lemon grass (*Cymbopogon citratus*) and tulsi (*Oscimum sanctum*) each at 10, 20 and 30% concentration to determine the optimal ratio of flower petals to aromatic plant powder for naturally fragrant incense sticks. The details of the treatments are presented in Table 3 and procedure for incense sticks preparation is given in Fig. 2.

**Table 1 : Different plant sources used in experiment 1 and 2**

Plant source type	Plant source	Part used
Flower crops	Rose ( <i>Rosa</i> spp.)	Petals
	Marigold ( <i>Tagetes erecta</i> )	Petals
	Chrysanthemum ( <i>Dendranthema grandiflora</i> )	Petals
	Mixed flower petals	Petals
Aromatic plants	Clove ( <i>Syzygium aromaticum</i> )	Buds
	Geranium ( <i>Pelargonium graveolens</i> )	Leaves
	Lemongrass ( <i>Cymbopogon citratus</i> )	Leaves
	Holy basil ( <i>Oscimum sanctum</i> )	Leaves
Adhesive agents	Cluster bean ( <i>Cyamopsis tetragonoloba</i> )	Endosperm
	Jigat ( <i>Litsea glutinosa</i> )	Bark

**Table 2 : Treatment detail of experiment I**

Treatment	Detail
T <sub>1</sub>	85% rose + 15% cluster bean powder
T <sub>2</sub>	85% marigold + 15% cluster bean powder
T <sub>3</sub>	85% chrysanthemum + 15% cluster bean powder
T <sub>4</sub>	42.5% rose + 42.5% marigold + 15% cluster bean powder
T <sub>5</sub>	42.5% rose + 42.5% chrysanthemum + 15% cluster bean powder
T <sub>6</sub>	42.5% chrysanthemum + 42.5% marigold + 15% cluster bean powder
T <sub>7</sub>	28.33% rose + 28.33% marigold + 28.33% chrysanthemum + 15% cluster bean powder
T <sub>8</sub>	85% mixed flower petals + 15% cluster bean powder
T <sub>9</sub>	85% rose + 15% jigat powder
T <sub>10</sub>	85% marigold + 15% jigat powder
T <sub>11</sub>	85% chrysanthemum + 15% jigat powder
T <sub>12</sub>	42.5% rose + 42.5% marigold + 15% jigat powder
T <sub>13</sub>	42.5% rose + 42.5% chrysanthemum + 15% jigat powder
T <sub>14</sub>	42.5% chrysanthemum + 42.5% marigold + 15% jigat powder
T <sub>15</sub>	28.33% rose + 28.33% marigold + 28.33% chrysanthemum + 15% jigat powder
T <sub>16</sub>	85% mixed flower petals + 15% jigat powder

# Incense stick from floral and aromatic plant materials

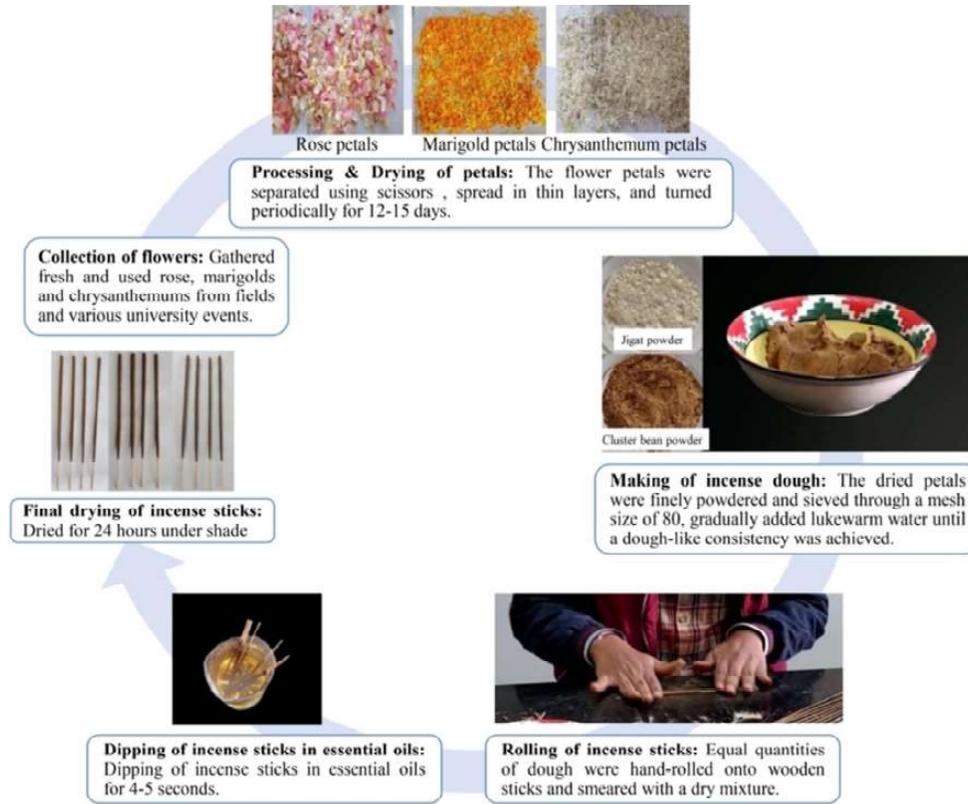


Fig. 1 : Methodology for preparing incense sticks in experiment 1

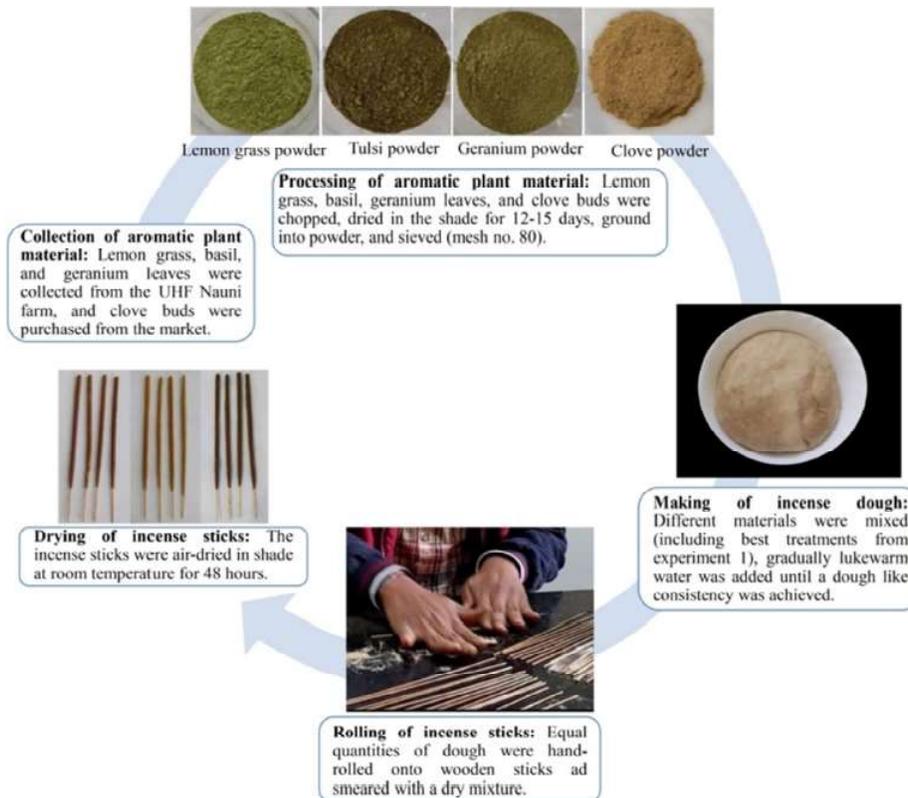


Fig. 2 : Methodology for preparing incense sticks in experiment 2

**Table 3 : Treatments details of experiment 2**

Treatment	Detail
C <sub>1</sub>	42.5% rose + 42.5% marigold + 15% jihat powder + clove 10%
C <sub>2</sub>	42.5% rose + 42.5% marigold + 15% jihat powder + clove 20%
C <sub>3</sub>	42.5% rose + 42.5% marigold + 15% jihat powder + clove 30%
C <sub>4</sub>	42.5% rose + 42.5% marigold + 15% jihat powder + geranium 10%
C <sub>5</sub>	42.5% rose + 42.5% marigold + 15% jihat powder + geranium 20%
C <sub>6</sub>	42.5% rose + 42.5% marigold + 15% jihat powder + geranium 30%
C <sub>7</sub>	42.5% rose + 42.5% marigold + 15% jihat powder + lemon grass 10%
C <sub>8</sub>	42.5% rose + 42.5% marigold + 15% jihat powder + lemon grass 20%
C <sub>9</sub>	42.5% rose + 42.5% marigold + 15% jihat powder + lemon grass 30%
C <sub>10</sub>	42.5% rose + 42.5% marigold + 15% jihat powder + tulsi 10%
C <sub>11</sub>	42.5% rose + 42.5% marigold + 15% jihat powder + tulsi 20%
C <sub>12</sub>	42.5% rose + 42.5% marigold + 15% jihat powder + tulsi 30%
C <sub>13</sub>	85% marigold + 15% jihat powder + clove 10%
C <sub>14</sub>	85% marigold + 15% jihat powder + clove 20%
C <sub>15</sub>	85% marigold + 15% jihat powder + clove 30%
C <sub>16</sub>	85% marigold + 15% jihat powder + geranium 10%
C <sub>17</sub>	85% marigold + 15% jihat powder + geranium 20%
C <sub>18</sub>	85% marigold + 15% jihat powder + geranium 30%
C <sub>19</sub>	85% marigold + 15% jihat powder + lemon grass 10%
C <sub>20</sub>	85% marigold + 15% jihat powder + lemon grass 20%
C <sub>21</sub>	85% marigold + 15% jihat powder + lemon grass 30%
C <sub>22</sub>	85% marigold + 15% jihat powder + tulsi 10%
C <sub>23</sub>	85% Marigold + 15% Jihat powder + Tulsi 20%
C <sub>24</sub>	85% Marigold + 15% Jihat powder + Tulsi 30%

In first experiment, observations like ease of rolling was recorded by giving task of hand rolling of each treatment to five semi-technical persons and according to their experience a scorecard was prepared (Table 4). Burning quality was recorded on the basis of length of incense stick burned at once and a scorecard out of five points was prepared (Table 4). Brittleness was recorded by dropping the incense sticks from 10 cm height on the floor and observations were recorded according to the level of damage caused by incense sticks on dropping. Those sticks which remained intact on dropping were allotted 5 points, slightly brittle were given 3 points and brittle incense sticks were allotted 1 point. The time of combustion was recorded with three incense sticks per replication in which incense sticks were burnt and the time of combustion (burning) for each incense stick was recorded by using a stopwatch. The rate of combustion was recorded by dividing the length (18 cm of coated

part) of each incense stick from its time of combustion. The rate of diffusion of fragrance was measured at a 2 m distance in a closed room. The time taken by fragrance to reach at a distance of two metres was noted and this 2 m distance was divided by reaching time, thus the rate of diffusion was calculated. The benefit-cost ratio for all the treatment combinations was calculated.

**Table 4 : Score card for ease of rolling and burning length**

Ease of rolling	Score	Burning length
Excellent	5	>16 cm
Very good	4	12-16 cm
Good	3	8-12 cm
Poor	2	4-8 cm
Very poor	1	1-4 cm

In second experiment, soot formation was recorded by burning 3 incense sticks per replication up to their full length and the weight of their soot so formed was taken. Mosquito repellent activity was recorded on a regular day basis at a time between 6:00 pm to 7:30 pm in July and August 2022 at farm of the Department of Floriculture and Landscape Architecture, Dr. Y.S. Parmar University of Horticulture & Forestry, Solan, Himachal Pradesh, India, where mosquito colonies were observed. Before burning of incense sticks approximate number of mosquitoes was counted and after burning of three incense sticks of each treatment number of mosquitoes left in the area was counted. The percentage of mosquitoes repelled was recorded by dividing the number of mosquitoes by an initial number of mosquitoes before burning incense sticks. To test naturally fragrant incense sticks, this test was done by burning and smelling of incense sticks. The evaluation was conducted by a panel of ten trained judge teams to differentiate between fragrant and non-fragrant incense sticks. The benefit-cost ratio for all the treatment combinations was calculated.

The data obtained during the research in both experiments was statistically analysed using SPSS

version 16.0 software (SPSS Inc., Chicago, IL, USA). Employing complete randomized design (Gomez & Gomez, 1984), a one-way analysis of variance (ANOVA) was performed on data and the treatments were compared at the 0.05% significance level.

## RESULTS AND DISCUSSION

Significant effect of different treatments was observed on parameters for making incense sticks during experiment 1 (Table 5). Maximum score for ease of rolling (4.98), burning quality (4.91), brittleness (4.94) and time of combustion (63.38) was recorded in treatment T<sub>12</sub>. Maximum rate of combustion (5.02) and diffusion of fragrance (112.47) were recorded in treatment T<sub>8</sub>. However, the ease of rolling score was found to be minimal in T<sub>1</sub> (2.26). Treatment T<sub>1</sub> and T<sub>2</sub> recorded minimum scores for burning quality i.e. 0.00. The brittleness score was also found to be the minimum in T<sub>1</sub>. The minimum time of combustion (0.00), rate of combustion (0.00) and rate of diffusion (0.00) was recorded in T<sub>1</sub> and T<sub>2</sub>, respectively.

The maximum ease of rolling, burning quality, and brittleness score was obtained in treatment T<sub>12</sub> (rose 42.5% + marigold 42.5% + Jigat powder 15%) might

**Table 5 : Effect of different flower petals and adhesive agents for making incense sticks**

Treatment	Ease of rolling	Burning quality	Brittleness	Time of combustion (in minutes)	Rate of combustion (mm/minute)	Rate of diffusion of fragrance (cm/minute)
T <sub>1</sub>	2.26	0.00	3.10	0.00	0.00	0.00
T <sub>2</sub>	3.05	0.00	3.40	0.00	0.00	0.00
T <sub>3</sub>	4.15	3.09	3.97	52.31	3.44	104.37
T <sub>4</sub>	3.86	4.01	4.73	51.03	3.52	102.00
T <sub>5</sub>	3.49	3.38	3.51	48.35	3.72	109.99
T <sub>6</sub>	3.80	3.60	4.11	52.67	3.42	95.18
T <sub>7</sub>	3.05	4.48	3.89	49.59	3.88	98.67
T <sub>8</sub>	3.11	2.45	3.97	46.38	5.02	112.47
T <sub>9</sub>	3.10	4.69	4.37	53.50	3.36	110.67
T <sub>10</sub>	4.97	4.89	4.92	58.62	3.07	92.65
T <sub>11</sub>	4.62	4.83	4.21	53.39	3.37	103.83
T <sub>12</sub>	4.98	4.91	4.94	63.38	2.84	90.62
T <sub>13</sub>	3.92	3.69	3.87	52.62	3.42	103.04
T <sub>14</sub>	4.09	3.95	4.26	55.98	3.22	95.28
T <sub>15</sub>	4.50	3.79	4.74	52.66	3.42	93.08
T <sub>16</sub>	3.78	3.86	4.23	50.09	3.59	101.87
C.D <sub>0.05</sub>	0.48	0.16	0.15	1.18	0.10	3.00

be due to the optimal balance and complementary properties of rose and marigold, enhancing texture and cohesion. Jigat powder's excellent binding and burning properties further improve the mixture's integrity and uniformity in burning. Similar results of excellent binding properties of jigat powder were also reported by Hazarika et al. (2019). Although, rose petals can be ground to a fine powder which makes them more elastic but rolling becomes tough and their sticks become hard because of more elasticity. Similarly, in all those combinations of treatments where cluster bean powder was used the sticks became hard and they lost their combustion property when compared to jigat powder. Therefore, T<sub>12</sub> was an ideal mixture. The specific proportions and interactions among these components create a synergistic effect, enhancing overall performance. Additionally, the particle size and distribution might have contributed to the ease of rolling and consistent burning. The maximum brittleness score for T<sub>12</sub> is likely due to the high affinity between its components, ensuring maximum intactness and preventing breakage when dropped. The combustion properties of incense sticks are influenced by the plant materials used and their interaction with available oxygen. Treatment T<sub>12</sub> recorded the maximum combustion time likely due to the balanced combination of rose and marigold with Jigat powder, which provided a steady, slow burn and gradual fragrance release. Raja et al. (2023) also reported that incense sticks containing jigat powder burn for longer duration. The highest combustion rate and fragrance diffusion recorded in T<sub>8</sub> might be due to the diverse mix of petals burning more rapidly. In contrast, T<sub>1</sub> and T<sub>2</sub> did not burn properly, indicating the importance of effective material combinations and binding agents for optimal combustion and fragrance diffusion.

Fig. 3 illustrates that the maximum benefit-cost ratios of 1.13 and 1.12 were observed in T<sub>10</sub> and T<sub>12</sub>, respectively. Consequently, these treatments, along with their other superior properties compared to the other treatments, were selected for use in experiment 2.

The data illustrated in Table 6 showed a significant effect of different treatments in experiment 2. The maximum rate of combustion (3.53 mm/minute) and soot formation (36.18 mg) was recorded in C<sub>19</sub>, while, the minimum rate of combustion (2.79 mm/minute) was observed in C<sub>9</sub> and soot formation (24.23 mg) was recorded in C<sub>3</sub>. The maximum rate of combustion and soot formation can be attributed to the high proportion of marigold and the composition of the ingredients. Marigolds, rich in organic compounds (Chauhan et al., 2022), tends to combust rapidly, contributing significantly to the high combustion rate. Jigat powder, used as a binding agent, ensures a steady and sustained burn, enhancing the combustion process. Additionally, the presence of lemongrass, although in a smaller quantity, adds to the overall flammability due to its essential oils (Baker & Grant, 2018). This combination results in a highly combustible mixture, leading to significant soot production during combustion. The maximum rate of diffusion (90.08 cm/minute) was observed in treatment C<sub>3</sub>. This can be attributed to the presence of a higher concentration of natural fragrance in dried clove buds, which, when converted into incense sticks, released a greater amount of pleasant aroma that diffused more rapidly. The remaining treatments were naturally non-fragrant, making it impossible to measure their diffusion rates, which were consequently marked as 0 cm/minute. Maximum percentage (65.52%) of mosquitoes repelled was shown by the treatment consisting of 'rose +

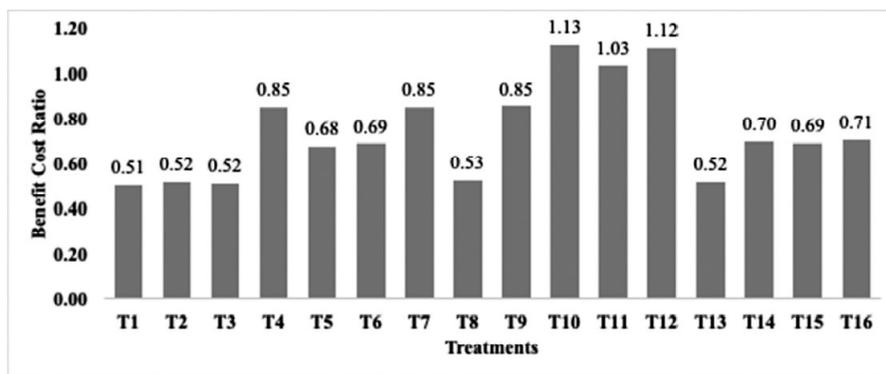


Fig. 3 : Benefit-cost ratio (Experiment 1)

**Table 6 : Mosquitoes repellent activity and olfactory evaluation of incense sticks made from different combinations of flower petal powder, adhesives and aromatic plants**

Treatment	Rate of combustion (mm/min)	Soot formation (mg)	Rate of diffusion of fragrance (cm/minute)	Mosquitoes repelled (%)
C <sub>1</sub>	3.03	26.17	87.67	40.74
C <sub>2</sub>	2.90	24.40	86.74	40.00
C <sub>3</sub>	2.97	24.23	90.08	47.37
C <sub>4</sub>	3.38	31.13	0.00	36.67
C <sub>5</sub>	3.32	28.82	0.00	38.10
C <sub>6</sub>	3.15	28.53	0.00	38.46
C <sub>7</sub>	3.51	34.52	0.00	59.26
C <sub>8</sub>	2.97	32.71	0.00	61.29
C <sub>9</sub>	2.79	25.52	74.40	65.52
C <sub>10</sub>	2.98	28.66	0.00	28.57
C <sub>11</sub>	3.33	28.09	0.00	29.17
C <sub>12</sub>	3.27	26.92	0.00	32.26
C <sub>13</sub>	3.36	26.18	83.98	36.11
C <sub>14</sub>	3.12	25.60	84.72	36.84
C <sub>15</sub>	3.27	24.92	87.77	40.91
C <sub>16</sub>	3.37	31.24	0.00	33.33
C <sub>17</sub>	3.46	30.14	0.00	35.48
C <sub>18</sub>	3.39	31.67	0.00	35.29
C <sub>19</sub>	3.53	36.18	0.00	55.56
C <sub>20</sub>	3.18	32.15	0.00	58.62
C <sub>21</sub>	3.16	26.63	71.68	63.89
C <sub>22</sub>	3.13	28.87	0.00	26.67
C <sub>23</sub>	3.38	28.28	0.00	28.57
C <sub>24</sub>	3.37	26.94	0.00	31.25
C.D <sub>0.05</sub>	0.16	1.00	1.37	1.65

marigold + Jigat powder + lemon grass 30%' i.e. C<sub>9</sub> and minimum percentage (26.67%) of mosquitoes repelled was shown by the treatment consisting of 'marigold + Jigat powder + tulsi 10%' i.e. C<sub>22</sub>. Maximum mosquito repellent shown by the treatment rose + marigold + Jigat powder + lemon grass 30% was due to presence of citronella oil in lemon grass. The present results are in accordance with the findings of Bahadur et al. (2020) and Valarmathi et al. (2021). The treatment repelled the highest percentage of mosquitoes, primarily due to the presence of citronella oil in lemongrass, which is a well-known natural insect repellent (Emmanuel et al., 2020). Citronella oil disrupts the mosquito's ability to locate its host by masking scents that attract them, highlighting the

critical role of specific active ingredients in enhancing mosquito-repellent efficacy (Muema et al., 2017).

Fig. 4 showed that, among the 24 varied treatments of incense sticks, a natural aroma was produced only by those made from clove powder and lemongrass paste. All six treatments containing clove were naturally fragrant, with the 30% clove oil treatments being the most aromatic. In contrast, only the 30% lemongrass paste treatments produced fragrance, but that too of very low intensity. These results can be attributed to the higher content of volatile oils (18%) present in clove buds (Francisco et al., 2014) and in lemongrass leaves (1-3%) (Majewska, 2019). In comparison, other materials like geranium leaves (0.05%-0.25%) (Verma et al., 2013) and tulsi leaves

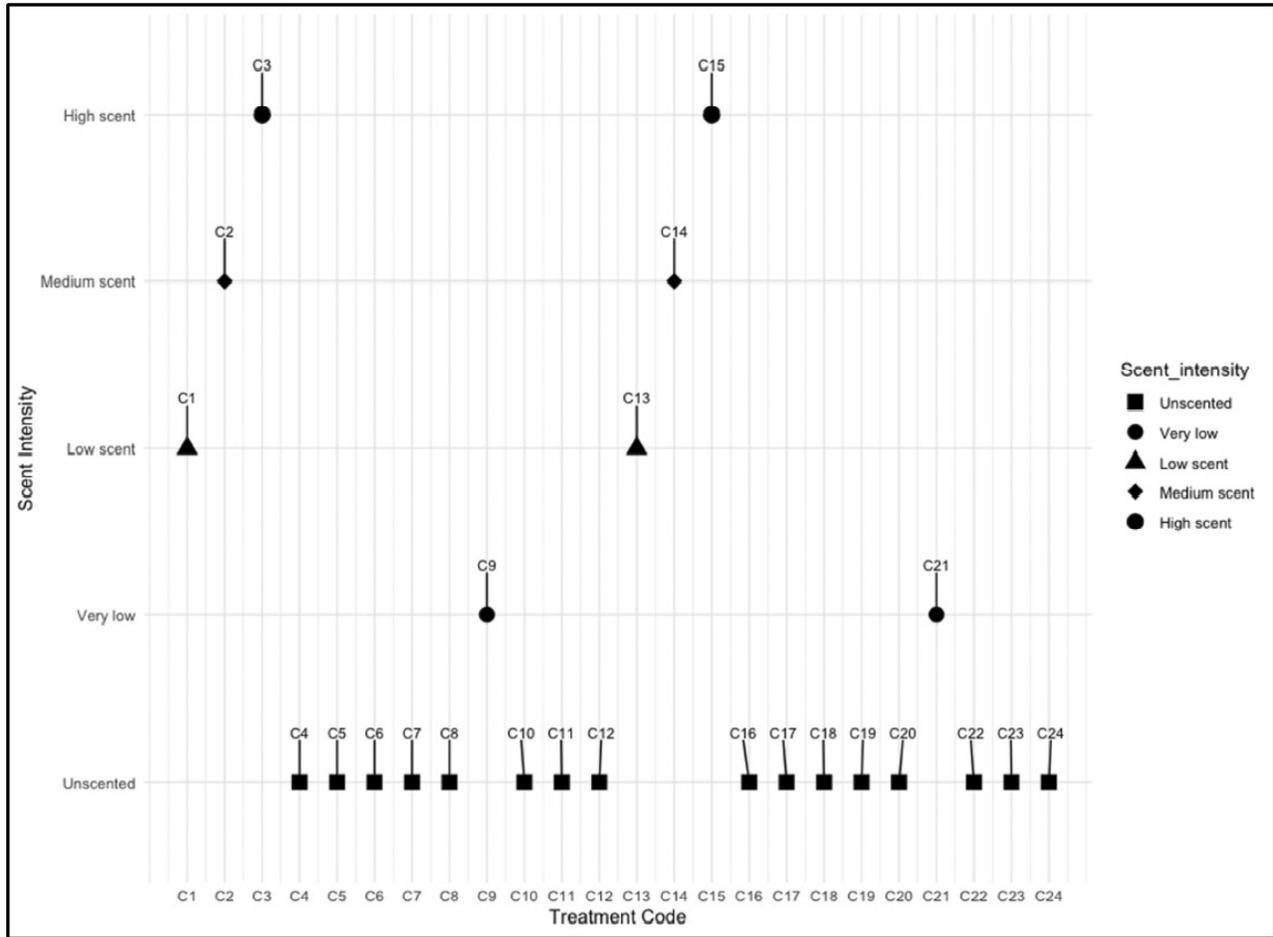


Fig. 4 : Scent intensity of different treatments

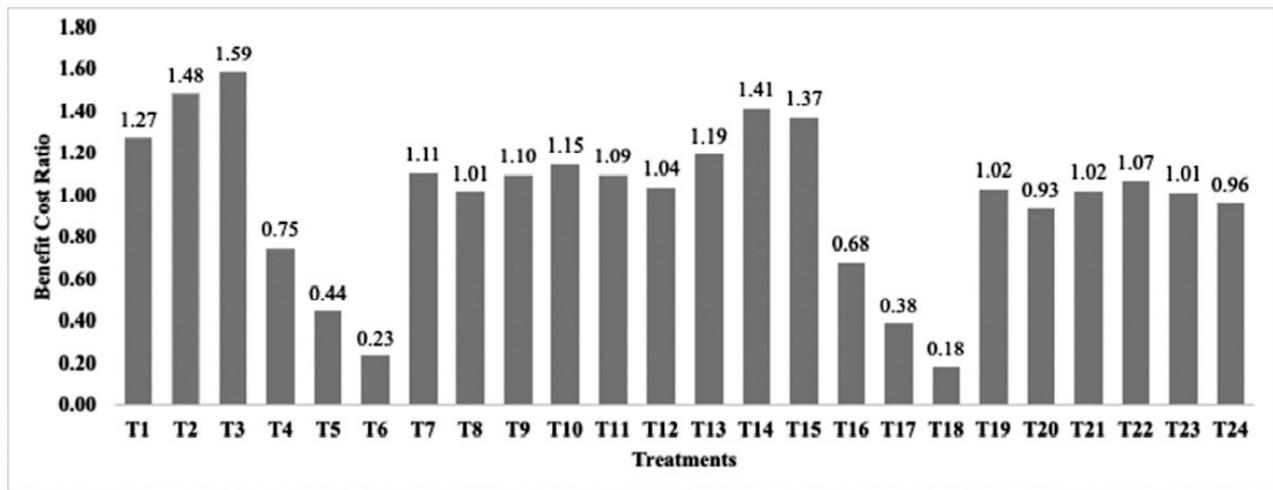


Fig. 5 : Benefit cost ratio (Experiment 2)

(0.017%) (Mushtaq et al., 2017) contain significantly lower amounts of volatile oils, making them less naturally fragrant. Fig. 5 illustrate that C<sub>3</sub> recorded the highest benefit cost ratio (1.59).

## CONCLUSION

The study on the preparation of environment-friendly incense sticks from flowers and aromatic plants concluded that incense sticks prepared with a

combination of 42.5% rose, 42.5% marigold, and 15% Jigat powder, followed by dipping in essential oil, resulted in high-quality incense sticks. Additionally, the best naturally fragrant incense sticks were produced by mixing 32.5% rose powder, 32.5% marigold powder, 15% Jigat powder, and 30% clove powder. These formulations highlight the potential for creating effective and environmentally friendly incense products using natural ingredients.

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